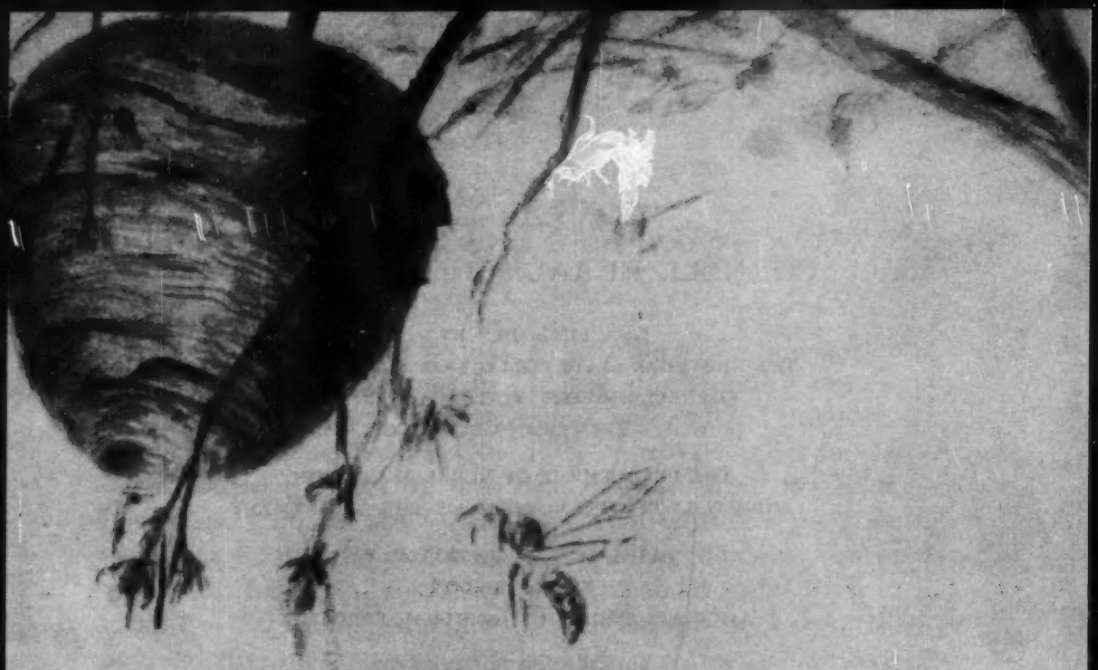

Cornell Rural School Leaflet

INSECT HOMES

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Insect Homes

By Eva L. Gordon

You may need to go no farther than your schoolground or the yard around your home to find an insect home. Perhaps you would not need even to go outdoors. Insect homes are in all sorts of places: in or on plants; in or on many kinds of animals; in cracks, crevices, tunnels, and burrows, indoors and outdoors; and even under water. Some insects make houses for themselves, or their young, of mud, or silk, or paper, or some other material. Others merely move into suitable places, such as hollows under stones or the furry coat of a dog or a cat.

Probably *house* is a better word than *home* for these places where insects live. In them, the insects find shelter, or food, or protection, or sometimes all three. Most persons get these things in their homes, and much more besides. You might like to discuss what you think is the difference between a house and a home.

Before you begin to look for insect houses, perhaps you should think or talk over what you know about insects. You may wish to go to textbooks or to other books in your library for information or to answer questions. You need to know some general things about these animals in order to understand what they do in their homes and what good their homes are to them. But first, you need to know about *insect lives.*

Insects hatch from eggs. Usually an insect lays her eggs on or near the food upon which the young are to feed. The eggs of some kinds of insects hatch within the body of the female, and we say the young are "born alive." Examples are frequent among the aphids.

Newly hatched insects differ more or less from their parents. All young insects are alike in one important way – their chief business is to eat and grow. As they grow they change their hard, outer covering or skeleton from time to time, a process called *molting.* When it is time for a molt, a new soft skin forms under the old one. The old skin breaks, the insect crawls from it, and stretches to a larger size before the new skin hardens. Different kinds of insects have different numbers of molts.

Other changes occur when the larvae (singular, larva) of certain kinds of insects are full-grown. Larvae, such as caterpillars of butterflies, then change to *pupae* (singular, pupa). A caterpillar and the butterfly it becomes differ greatly. During the pupal stage the caterpillar is "made over" into the butterfly. In most insects, but not all, the pupal stage is a time of quiet change. It may be long or short. When an insect changes from *egg* to *larva* to *pupa* to *adult* it is said to have *complete metamorphosis.*

Some insects, such as grasshoppers, do not pass through a pupal stage. As they grow and molt, they become more and more like adults of their kind. They change from *egg* to *nymph* to *adult,* and are said to have *gradual metamorphosis.*

Adult insects, with a few exceptions, do not molt. Neither do they grow. Their important business is to produce a new generation of insects of their kind. Eggs must be laid. How they and the insects that hatch from them are protected is a question with many answers. Insect homes are one answer. You will have fun looking for these houses, and discovering some of the interesting ways in which insects get food, shelter, and protection for themselves or their young.

Homes in or on Plants

No plant part escapes service as some kind of insect house. You will find insects tucked away in leaves, in stems, in roots, in flowers and fruits, and even inside seeds. This Leaflet can tell you only a little about a few of them. You may not find these same plant-dwellers, but what you read about them here may help you to learn about those you do find.

Insect Galls and Their Makers

Almost everyone who lives where goldenrods grow has seen on some stems ball-like swellings or *galls,* like those shown on page 5. If you cut open one of these galls any time from September to late winter, you will probably find inside it a fat, white, legless insect larva about ¼ inch long. That larva is the young of a pretty fly with banded wings. Its parents emerged from other goldenrod-ball galls, probably in late May or early June, and mated. The female then found young goldenrod plants of the right

kind (there are many kinds of goldenrod, you know) and laid her glistening white eggs in the unfolded leaves of the bud at the tip of the plants. Usually she put one egg in each bud she visited, placing it in a little hole she made with a part of her body called the *ovipositor* (egg-placer). The eggs probably had hatched before the end of June.

Each young larva bored down into the growing part of the stem and began to eat out a chamber. A gall began to form. Scientists who have studied this insect believe that some material given off (secreted) by the larva causes the plant stem to grow into a swollen

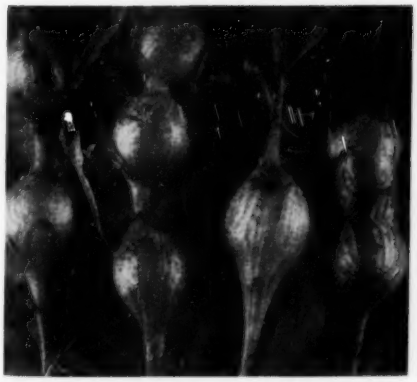


Photo by L. D. Uhler

Galls from one field

Single galls are common. Double and triple galls are probably caused by larvae from eggs laid at different times, perhaps by different flies. Each larva has its own chamber. Average diameter of gall is 1¼ inches.

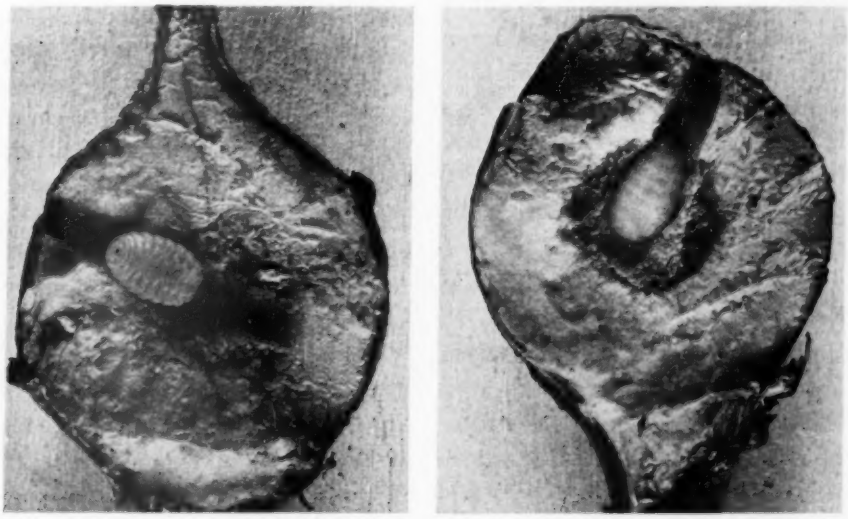


Photo by L. D. Uhler

Two goldenrod-ball galls, cut open

Left, a full-grown larva and its prepared exit; right, a pupa in an overwintered gall

Photo by L. D. Uhler

Emerging adult fly, ready to use its front legs to help free itself

ball around the insect, much as a mosquito bite causes a swelling in you. The swelling was large enough to be seen three or four weeks after the fly laid her egg. It grew to full size within another month or so. The goldenrod plant grew, too, almost as if the gall were not there.

The fly larva inside lives a sheltered life. The walls of its house furnish plenty of the right kind of food. By early fall it is full-grown. It spends the winter in the gall, snug but not warm, sheltered from the weather, and protected somewhat from enemies and from sudden temperature changes.

Before winter comes, the goldenrod-ball dweller digs a hole through the pithy wall of the gall. It uses its mouthparts as tools, and pushes the scrapings past it into the central chamber. It stops its digging just inside the outer covering, or *epidermis,* of the gall. You can find this exit hole easily in most galls. It usually extends upward from the central chamber.

Sometimes in late March, but usually in April, in New York State, the larva changes to a bronzy-brown pupa. By middle or late May the adult fly is ready to emerge. It uses the passage it had prepared as a larva the fall before, and breaks through the thin epidermis over the outer end.

This emergence is worth seeing. You may see it if you gather several galls late in April or early in May. Put them in a glass jar, and cover the jar with thin cloth. Leave the galls outdoors in a shaded place where you can easily watch them—outside a window will do. This is what happens. The emerging fly has a pale, fleshy sac, called a *ptilinum,* on the front of its head. With this it breaks the covering of its exit. Then by contracting and expanding its ptilinum and its body, it squeezes out of the gall, taking about three minutes to do so. About ten minutes later its wings

are fully expanded, and its helpful ptilinum has disappeared into its head. A short time later mating may occur and more eggs may be laid. The adults usually live about two weeks.

This story so far has told what happens if all goes well with the gall-dwellers. Sometimes birds dig into the galls and eat the larvae. Sometimes other insects prey on them or make homes in the walls of the galls. Either of two important enemies, both relatives of the ants and bees, may feed on and finally kill the fly larva, take its place in the gall during the winter, and emerge as an adult in the spring. Do not be surprised if some insect other than a pretty two-winged fly with banded wings comes out of some of your galls.

Galls Differ. The goldenrod-ball is one of about 2000 kinds of galls known to North America. Each kind of gall-dweller has its own somewhat different way of life. Each produces its own special kind of gall, usually on a particular part of a favorite plant or plants. Some galls are caused by tiny spider relatives called *mites*. A few are caused by fungi or are produced in other ways. Most are the result of irritation to a plant by an insect. The insect may be a female laying her eggs or, more frequently, as in the goldenrod-ball gall, a newly hatched larva. The insect does the irritating but the plant really makes the gall and thus provides food and shelter for the gall dweller. Usually the gall does little real harm to the plant. Most galls begin to form while the plant parts are growing rapidly.

Among gall-insects, the greatest number of kinds are tiny wasps. They cause closed galls, such as the goldenrod-ball gall. Oaks are their favorite homes. Small, delicate two-winged flies called *gall-midges* come next in importance. Some plant lice or aphids are gall producers, too,—their galls always have an opening through which the inhabitants can leave their home. A few other kinds of insects also cause galls. Most insect gall dwellers are larvae; many

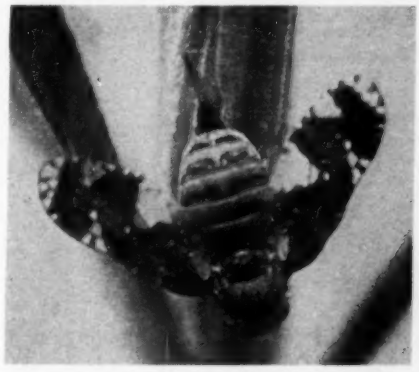
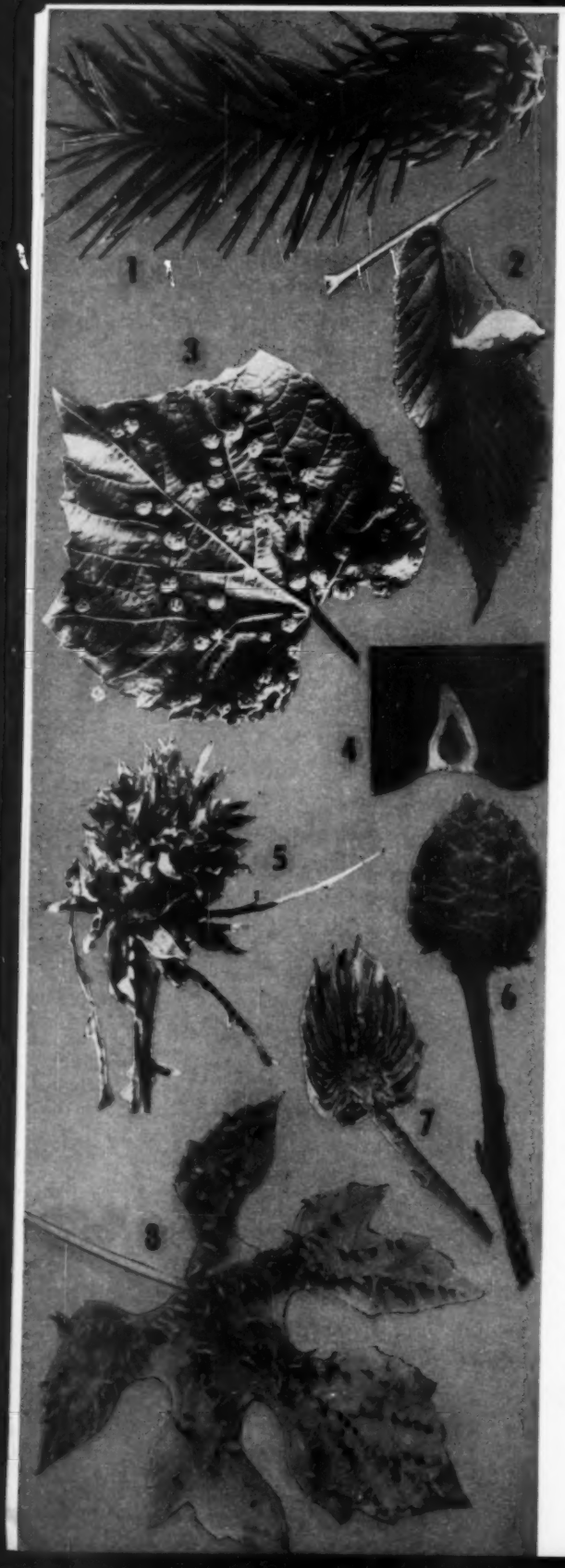


Photo by L. D. Uhler

Goldenrod-ball gall fly
Female with ovipositor extended, x about 3



kinds pupate (change to adults) in their galls.

There are far too many kinds of galls to learn by name, but you can learn other things about those you find. See how many kinds of plants you can find that seem to have galls. Are there insects inside the swellings? How many kinds of leaf galls can you find? stem galls? flower, fruit or bud galls? root galls? Put together soft, tender galls; hard, woody galls; galls with only one chamber and one insect inside, and galls with several chambers and several insects. Look for empty galls with holes through which the inhabitants have escaped. Look for open galls—some may be mere hollows in leaves, sometimes filled with matted plant hairs. Others may be pockets or folds of various shapes. Look for closed galls. Look for ways in which the galls differ from or resemble the natural parts of the plant on which they grow.

If you do some of these things, you are almost certain to discover far more interesting things about galls than just their names. You can find galls at any time of year. You will see different things in different seasons. The goldenrod-ball fly's way of life was discovered by students who watched through all the seasons. You, too, can learn much by watching.

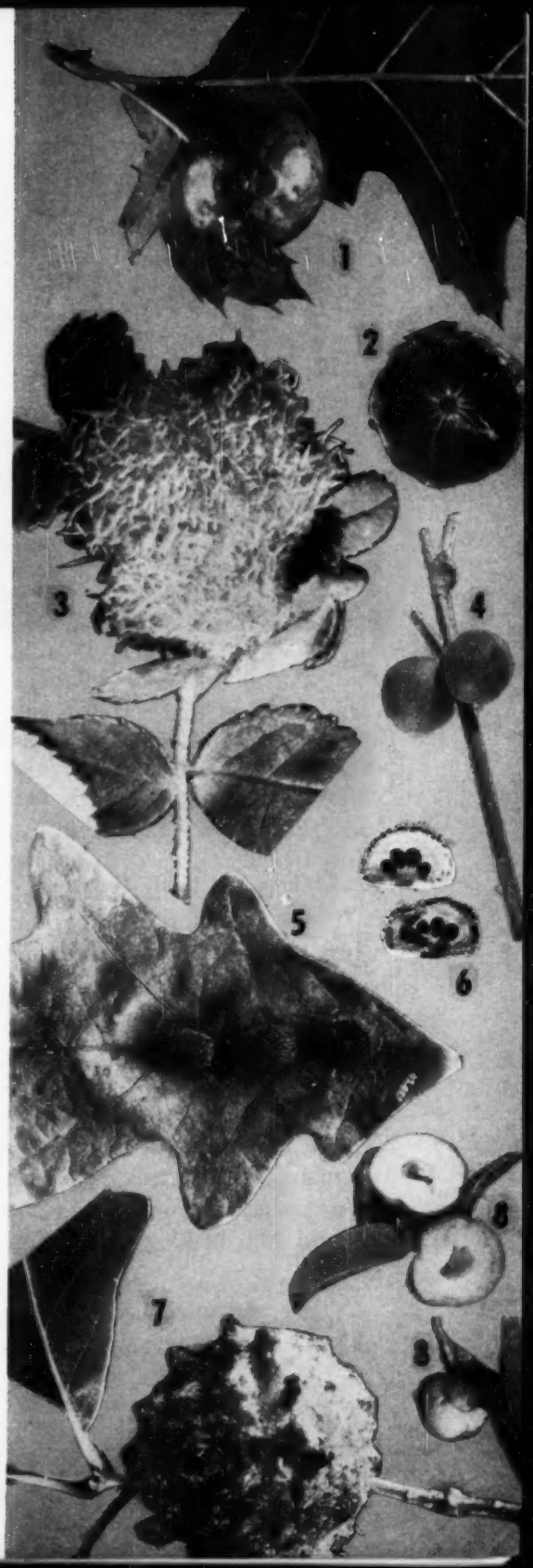
Some Insect Galls

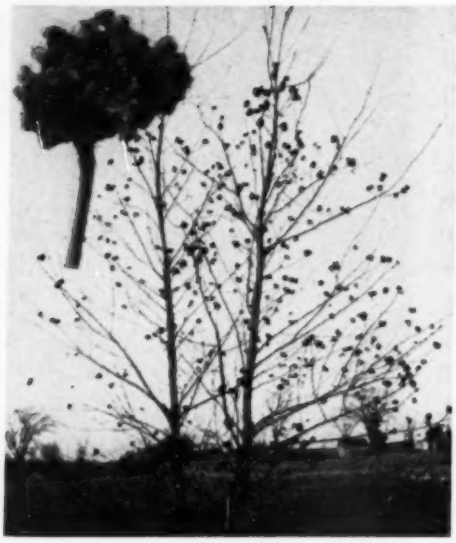
Page 8. The spruce cone gall (1), the slippery elm pouch gall (2), the grape Phylloxera gall (3), and the witch-hazel cone gall (4), are caused by aphids. Such galls are open and house whole families. Gall 4 is cut to show the opening and the hollow interior.

The goldenrod bunch gall (5), the willow pine-cone gall (6 and 7), and the grape tube gall (8), are caused by gall-midges. Gall 7 is cut to show the inside.

Page 9. Galls 1 through 7 are produced by gall wasps. They are: the larger empty oak apple (1); an oak apple (2), cut to show the larval cell in the center, held by threads of plant material (some oak apples are spongy inside); the mossy rose gall (3); the oak bullet gall (4); the oak hedgehog gall (5); oak hedgehog galls cut to show the cells inside (6); and the wool sower on oak (7). Galls 3, 5, and 7 house several larvae, each in a separate cell. The willow apple gall (8) is caused by a sawfly.

Galls pictured are about ⅔ natural size. On page 8, photos 2 and 8 are from Buffalo Society of Natural Sciences; 5, 6, and 7 by V. N. Rockcastle and R. B. Fischer. All others are from the Department of Entomology.





Photos by V. N. Rockcastle

Poplar vagabond gall

Infested tree, and (inset) a gall, about ½ natural size. Leaves become hollow sacs, within which aphids live.

Goldenrod elliptical gall

Left: a gall opened to show its cause, a moth caterpillar; right: exterior view, about natural size

Leaf-Mines and Leaf-Miners

If you look for insect homes when leaves are on the trees and gardens are growing, you are almost certain to find *leaf-mines.* Leaf-miners mine and live inside nasturtium leaves, beet leaves, grass blades, poison-ivy leaves, maple leaves, and leaves of many other kinds of plants. Some even find room to live and eat and grow inside part of a pine needle.

There are hundreds of kinds of leaf-miners. Some live in only one kind of leaf; others are not so particular. Some kinds of plants are favorite foods of several different kinds of miners. You may find more than one kind of mine on even a single leaf, especially in the fall.

Think what a home inside a leaf would be like. Leaves are covered on both sides by a thin, clear, transparent "skin," called the *epidermis.* Between the upper and the lower epidermis are layers of green cells that make food for the plant (and, inci-

dentally for the miners). When tulips begin to grow in the spring, you can easily see these parts of a leaf. You can peel off first one and then the other epidermis and expose the soft, moist tissue inside. Even a tulip leaf has a "low ceiling," doesn't it? And tulip leaves are thicker than many other kinds of leaves. It is no wonder that leaf-miners are small and often flat! Only a tiny creature could live in so small a place.

The tiny animals that mine in leaves are all insect larvae. Some are caterpillars (moth larvae); some are the larvae or maggots of true, two-winged flies; some are beetle grubs. A few are sawfly larvae, not true flies, but relatives of the ants, bees, and wasps. Do not expect to tell them apart easily. They look much alike—tiny, worm-like, and usually flat. More kinds of miners are moth caterpillars than are members of any other insect group, and leaf-mining caterpillars are probably the most skillful miners.

Each miner makes a mine like others of its kind. You will find two main forms of mines: *linear* mines and *blotch* mines, but there are combinations of the two, and mines of many sizes and shapes. Linear mines may be straight, curving, or winding. They usually widen as the insect inside grows and needs more room. Blotch mines are broad patches of almost any size and shape, that increase in size as the miners feed and grow. Some mines show best on the upper side of the leaf; some on the lower side; and still others can be seen easily from either side.

Like human beings, leaf-miners have "garbage," "trash," and "sewage" to dispose of. Such waste materials are called *frass,* and in many mines show as dark bits or patches. Most leaf-miners have their own way of keeping a free working space and clean food. Perhaps you can find one that leaves its frass in a neat line behind it, or one that gathers it in a particular part of the mine. Some tie it in packets with silk.

Leaf-mining insects all pass through four life stages: egg, larva, pupa, and adult. The mother insect places her eggs on the surface of the kind of leaf her kind of miner likes to eat, or inserts them into the leaves. When a larva hatches, it often eats its way directly from the egg into the leaf, with not even a minute without shelter. Some miners seem to slip out of one mine and into another at will. Some spend only part of their larval lives as miners, but most spend all of that

stage in a single mine, and some pupate there (change from larva to adult). What a snug way of life, with the leaf epidermis for protection, the inner parts for food, and only the veins to get in the way!

Leaf-miners that do not pupate in their mines may do so in some sheltered place outside, or in or on the ground. The adults that emerge at the end of the pupal stage are small. Probably most would measure less than ¼ inch from wing-tip to wing-tip when their wings are spread wide.

Even in as snug a shelter as a mine, the insects are not always free from enemies. Other kinds of insects feed on them and birds eat some of them. Mice and shrews are believed to take some miners from their winter quarters in or on the ground, and red squirrels, too, hunt out the overwintering larvae of a beetle-miner in fallen oak leaves. Leaf-miners also have *parasites*—enemies that live in or on their bodies and usually cause them to die before they can become adults. Sometimes men kill them with sprays or in other ways when they become pests. Yet, for the most part, leaf-miners do little harm to the plants whose leaves they inhabit. "Live and let live" is a fairly good description of their way of life.

You may not find the particular miners illustrated on pages 13 and 14, but you are almost certain to find several kinds. Try to do some of these things: (1) Find as many kinds of mined leaves as you can. (2) Look for linear mines, blotch mines, and others. (3) Look for mines that show best on the upper-surface of the leaf; on the lower-surface; and for full depth mines that show well from either side. (4) In late spring or early summer, mark a mined leaf by tying a string loosely around its stalk, and keep a record (drawings will help) of the miner's activities through the season. (5) Find mines whose course was changed by leaf veins. (6) Find leaves in which you can see the miners when you hold the leaves toward light. (7) Collect examples of different ways of frass disposal. (8) Find openings by which miners left their tunnels. (9) In the fall, look for miners pupating in leaves—some make a special pupating space, some do not. (We will be proud of you if you can find some pupating in other places.) (10) If you find pupating miners, put some in jars covered with thin cloth, place them in a sheltered place outdoors, and wait patiently to see whether adults emerge.

Mines of Moth Caterpillars

The digitate blotch miner on common or black locust (1) first makes a small lower-surface mine, then moves to upper side. It puts frass in its first mine. It pupates in a cocoon outside the mine.

The miner of the upper-surface blotch mine on sugar maple (2) pupates in a cocoon in an oval chamber in a clean part of the mine.

The trumpet leaf-mine on apple (3) usually does not cross large veins. The caterpillar lines its mine with silk and hibernates and pupates there. Often a pest.

The plum leaf-mine (4) is first narrowly linear, then a wide blotch. The miner, sometimes a pest in orchards, pupates on the ground in a small flattened brown cocoon.

The full-depth blotch mine on grape (5) is enlarged. Its maker pupates on the ground in a silk-lined case cut from the mine (see hole), usually far from the frass (dark spot).

A blotch mine on oak (6), enlarged, shows the miner in its pupal chamber. A similar chamber is made by (2).

Photos 2 to 6 are from the Department of Entomology; 1, from Photo Service. Mines 1 through 4, about ¾ natural size.

From Department of Entomology

Mines of Fly Larvae (above)

The maker of the linear mine of columbine (1) fastens its brown, football-shaped pupal case near its exit at the end of the mine.

The miner of the linear-blotch on jewelweed (2) transforms outside its mine. The female flies often suck plant juices from holes they make in leaves.

The mine on pigweed (3), made by the beet or spinach leaf-miner, at first threadlike, is soon a blotch. The insects become adults in the soil.

The blotch-mined burdock leaf (4) is about 1/5 natural size; the others about 3/4. Drawings, below, 1/4 to 1/2 size.

Beetle and Sawfly Mines (below)

The oak leaf-miner (left), a beetle larva, spends the winter in its mine in a fallen leaf. Squirrels may find and eat it.

Linear mines of the plantain flea-beetle (center) often almost fill broad-leaved plantain leaves. Miners transform in soil.

A sawfly larva is shown in its blotch mine on purple-flowering raspberry (right). It transforms in soil in a thin cocoon.

Drawings by Katherine Wolf

Leaf-Rollers and Leaf-Folders

Late every summer the basswood trees in my woods look as if someone with scissors and thread had been at work on the leaves. Sometimes nearly every leaf is cut halfway or more across the middle, and the loosened flap rolled into a tube.

Little white ropes of silk from the roll to the leaf hold each tube fast. If you break these tiny bands and carefully unroll this insect house, you may find other fastenings made earlier when the roll was smaller. You will almost certainly discover that the interior is well eaten, and you may uncover the "someone" that made the roll and did the eating—a small, bright green moth caterpillar with a shiny black head. Its jaws are its scissors. Silk from a gland near its "lower lip" is its thread. When it is almost too small to be seen, it begins its roll by fastening down a folded-over leaf-edge. It enlarges its house as it grows, thus providing itself with shelter, protection, and plenty of food.

When the basswood leaf-roller has finished feeding, it retires to a smaller house, usually made of a folded-over leaf-edge, lined with silk. It spends the winter there, and the next summer changes to a pupa, and then to an adult moth.

From Department of Entomology

A basswood leaf-roll, x about ½
Note the three white ropes.

You may find leaf-rollers on many other kinds of plants. Staghorn sumac leaflets often are rolled into what Mrs. Comstock, in the *Handbook of Nature Study,* calls "little cornucopias fastened with silk." The small moth caterpillars that make these rolls commonly use a single leaflet at first, but later may fasten together 2 or 3 leaflets. Witch-hazel, too, has a special kind of leaf-roller, and a common leaf-folder that bends over and fastens down a fold of a leaf. Insects of many kinds make such shelters. Each kind of roll or fold has its own special maker that usually

uses and eats only the kind of leaf on which you find it.

On how many kinds of plants can you find leaf-rollers or leaf-folders? Can you find rolls of different shapes? Can you find some made of one leaf or leaflet and others of more? Are the silken ropes larger where they are attached, or at their center? If you can, examine the ropes with a magnifying glass to see the many fine threads in each cable.

If you find a leaf-roller or a leaf-folder "at home," move it gently to a fresh leaf of the same kind. You may be fortunate enough to see it make a new house, a truly wonderful thing to watch.

From Handbook of Nature Study

Witch-hazel, showing work of leaf-rollers, leaf-miners, and gall-makers, x about ½

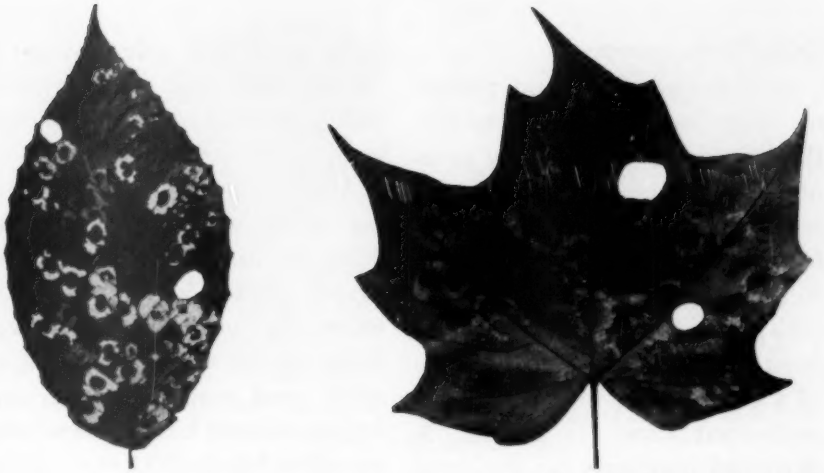
Other Leaf-Dwellers

You are sure to find many kinds of leaf-dwellers not described in this Leaflet, all different and all interesting. Here is the story of one I look for every summer. It is called the maple-case-bearer. I had read about it in *Ways of the Six-footed,* by Mrs. Anna Botsford Comstock. One September, I found it in my woods.

A maple-case-bearer is a tiny moth caterpillar. The adult moths are steel-blue and smoky brown with a tuft of orange-yellow hairs on their heads. They are small, with a wing-spread of about ½ inch.

In New York State, they lay their eggs in May, usually in tiny pockets in young sugar-maple leaves. For about 10 days after the larva hatches, it is a leaf-miner. Then it cuts a rounded piece from the leaf, turns this piece upside down over its body, and pegs its "tent" down with silken cords. It feeds by thrusting out its head and eating a narrow strip of leaf around its case. When its pasture is exhausted, it breaks its tent ropes, and looking like a tiny turtle, it moves its tent by "grabs and pulls" to a new location where there is a fresh food supply.

In the picture on page 17 some



From Department of Entomology

The maple case-bearer
On beech (left); commonly found on sugar maple (right)

of these "camping grounds and pastures" show. The roundish uneaten spots were under the case. The ring-like areas around these spots are where the green leaf-material had been eaten, and only leaf-veins remained. The holes in the leaf were made when the little case-bearer cut bigger and bigger cases as it grew and needed more room.

I have watched the little worker do this. It stretches out of its case, and with its jaws, cuts a larger oval, all around the old case, leaving little "bridges" on each side from the new case to the leaf. Then, reaching far out, it grasps the leaf surface beyond the cut it has made, and pulls one edge of the new case up onto the leaf. (Mrs. Comstock says it first fastens this edge to the leaf with silk, which would seem a good thing to do when one is "sawing off the limb he is sitting on.") The little bridges it left must snap as the caterpillar pulls, since it seems to have no difficulty slowly moving the new case to a fresh location. There it flips the new tent over, turning inside so that its old cover becomes a rug beneath it. It pegs down its new shelter and goes on feeding. During its larval life it molts several times and makes several new and larger cases. It changes to a pupa in the last and largest case and falls to the ground with its leaf. It emerges the next spring, an adult moth.

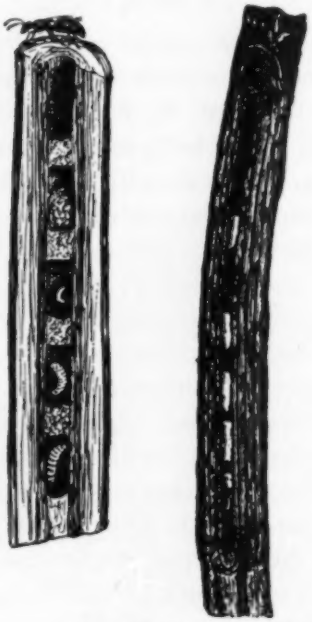
Unfortunately, when they are abundant, the maple case-bearers may injure the trees on which they live.

Other Plant Homes

Leaf mines, galls, and rolled-up leaves usually are easy to see. But, tucked away in many parts of many plants are hidden insect houses much harder to find. Often signs of their presence are to be seen if you have sharp eyes and know what to look for. Perhaps a pile of sawdust at the base of a big, old tree may tell of carpenter-ant tunnels inside. A shriveled blueberry tip may lead you to where a plump stem-borer finds food and safe living. A "worm-hole" may show that a codling-moth caterpillar enjoyed your apple before you could.

A whole Leaflet could be written about such insect shelters. Some are in buds and cause misshapen plants. Some are in dead wood, and some in living trees. Some are in soft stems, some in roots, and some in seeds and fruits of many kinds. Even fungi are often infested. Most of the insects that make these houses do their boring while they are larvae, but some adult females bore places for their eggs. Some kinds of larvae leave their homes before they change to adults. Other kinds make the change within their burrows, and some kinds of newly emerged adults remain for a time, often the winter, in the burrows they bored as larvae.

The illustrations of this page and on page 19 show a few examples of such insect dwellings. How many kinds can you find?



From Handbook of Nature Study

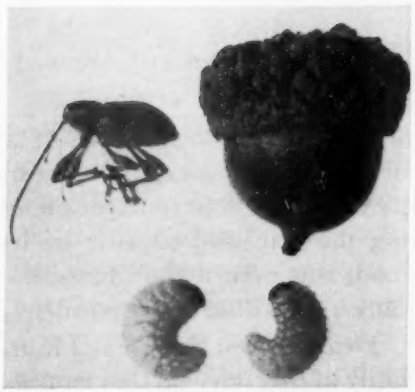
Burrows in dead twigs, enlarged

The little carpenter-bee (left) partitions her nest with tiny chips; the carpenter-wasp (right) with mud. In both, the oldest larva is at the bottom of the nest.

From Department of Entomology

The burdock moth, enlarged

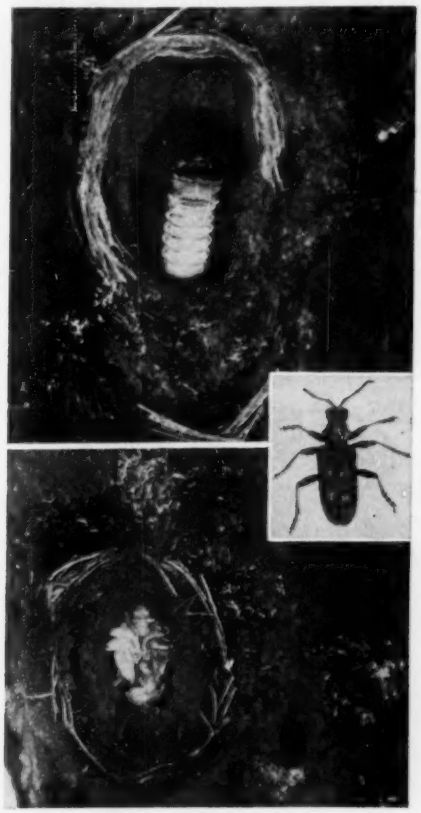
The larva fastens burdock "seeds" together, eats through them, winters in its "cave."



Acorn-weevil grub hatches in a hole bored by the female's beak; makes its own exit (top right)

An apple-seed chalcid at home in an apple seed

Above, a bark beetle larva in its pupal chamber; below, burrows and emergence holes of beetles



Ribbed pine-borer larva (above) and pupa (below), each in a nest of chips. Inset, an adult.

Photos from Department of Entomology

Homes on or in Animals

USUALLY, when insects make their homes *on* living animals, they simply move into a place where shelter, protection, and food can be had for the taking. Most insects that do this are well fitted to take what they need from their hosts and to escape natural hazards while they do it. Man has been able, however, to devise ways to control them when they are pests.

The cat or dog flea is a good example. Its body, flattened from side to side, and without wings, allows the flea to squeeze easily through the narrow spaces between the hairs of its host. Its smooth, hard covering helps it to slip from the fingers of a person or the teeth of a tormented dog, and its long, strong legs enable it to leap quickly away. Its mouthparts are excellent tools for piercing the skin and sucking in its food. But even a flea cannot endure a good dose of flea powder.

A dog flea, much enlarged

Fleas are best known as adults. Only in that stage do they trouble us and our household pets. They hatch from eggs, and when the slender, worm-like larvae are fully grown they pass through a pupal stage inside a cocoon. Fleas of various kinds live on bats, rats, mice, man, and other kinds of mammals and on birds.

Can you think of other insects that make their homes on living animals? You may be surprised when you begin to learn about lice—there are so many kinds, and they annoy so many hosts.

Fleas and lice are *parasites.* Parasites live on or inside the bodies of other living things (plants or animals), and get food and often protection at the expense of their hosts. Either plants or animals may be parasites. They cause more or less injury to their hosts, but the hosts usually survive the injury at least as long as they are of use to the parasite. Parasites that live inside their hosts are called *internal parasites;* the others are *external parasites.*

Internal Parasites

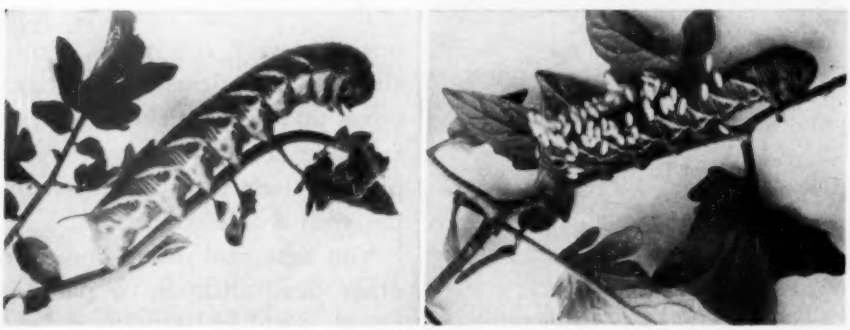
A third-grade class had a big, green tomato "worm," the caterpillar of the tomato Sphinx moth. They kept it in a wire cage and fed it fresh tomato leaves. One day a boy called out, "Look, look, our caterpillar is sweating." Everybody went to look, and this is what they saw. Little, oily drops that did look like sweat were coming from small holes on the caterpillar's back. A little later small, whitish, worm-like grubs came out through the holes. Each grub soon made a tiny, white silk cocoon, which it fastened to the caterpillar's back. The caterpillar died.

Some days later the children found the cocoons empty, with neat little silken lids lifted up from their tops. In the cage were small four-winged, wasp-like insects with slender "waists," the adult parasites of the tomato worm.

These parasites had hatched from eggs placed within the caterpillar. The young larvae had fed inside their host's body until they were grown and the weakened caterpillar died. Then they made cocoons in which they passed their pupal stage. The new adults perhaps found other tomato worms in which to lay their eggs, and probably there were fewer tomato worms to eat the next year's tomato leaves.

Many kinds of insects are parasites of other insects. Some place their eggs in the eggs of the host insects (one kind chooses tent-caterpillar eggs). Some lay them in larvae, some in pupae, and others in nymphs or in adults.

Even tiny aphids or plant lice, rarely longer than 1/8 inch, are victims of a small wasp-like para-



From Department of Entomology

Caterpillars of the tomato Sphinx moth

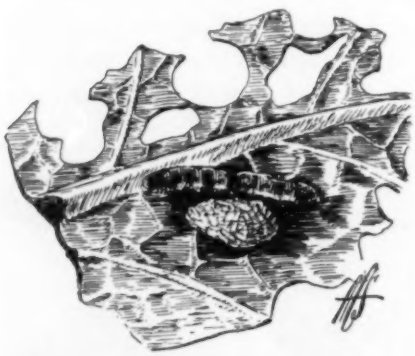
Left, a normal caterpillar; right, a parasitized caterpillar, showing cocoons in which parasites transform to adults

site. It lays its eggs in aphids' bodies. Its larva feeds inside its host. The aphid dies. Later, the adult parasite emerges.

Other kinds of animals are hosts to internal insect parasites, too. Horses and sheep, for example, sometimes are troubled by bot-flies, and cattle by warble-flies. And there are many more. Each kind of parasite commonly attacks only certain hosts.

A Suggestion

At first thought, parasites would seem entirely harmful. Many kinds, however, help to keep crop and other pests in control. All of them help to maintain that relationship among numbers of living things, sometimes called "the balance of nature."



A parasitized cabbage-worm, x about 1

Parasites that killed this cabbage-butterfly caterpillar spun tiny silk cocoons nearby. Similar parasite cocoons may be found on grasses or other plants.

You may wish to learn more about parasites. More kinds of living things than you may think are infested by them, and many parasites have parasites of their own. In fact, there is much truth in the following verse:

"Great fleas have little fleas
Upon their backs to bite 'em,
And little fleas have lesser fleas,
And so *ad infinitum*."

—From *A Budget of Paradoxes*, 1872, p. 377

Augustus De Morgan (1806–1871)

Dwellers in Dead Animals

If you have ever kept an insect collection, you probably know too well the tiny Dermestid beetles, about an eighth of an inch long, whose larvae make their homes in your specimens. You may have found the plump, hairy grubs or the fine dust that falls from infested specimens. Probably you have learned that tight boxes and regular chemical warfare are absolutely necessary to prevent these pests from destroying your whole collection.

You may find insect homes in other dead animals, or parts of them, such as skins, fur, and feathers. Many insects live in such places, and find enough to eat of food they like.

Homes in Crevices, Burrows, and Tunnels

Outdoor Homes

A leaf-lined tunnel. The lawn behind my house rises sharply to a small orchard. The steep bank is dry and sunny, and the soil is light and crumbly. Early one warm, bright September afternoon, three of us sat at the top of the slope to rest. An insect, a bee we thought, flew near. It seemed to be carrying something light-colored. It circled for a moment, then disappeared under a nearby fallen leaf. We investigated. Under the leaf was a hole in the ground about as wide as my little finger. As we examined it, the bee backed out, without its burden, and flew off across our garden. When it returned, we could see that it carried, beneath its body, a piece of rolled leaf long enough to extend beyond the end of its abdomen. This it pulled into the hole, remaining inside for two minutes. Three minutes later it was back at the nest with another piece of leaf about the same size as the first two. The next pieces it brought looked smaller.

By following the direction of its flight we traced it to a large sugar maple tree about 75 feet from its nest. That, we decided, was where it got its pieces of leaf.

What was it doing? Probably this is the story.

The bee was a leaf-cutter bee, at work on a house for her young. She probably had dug her own burrow, although some kinds of these bees use convenient, ready-made holes in the ground or cavities in wood, spaces between shingles, or other such places.

Her burrow may have been several inches deep. She used the large pieces of leaf to line the wall at its lower end for a space about as long as her body. She fastened the pieces with a glue-like material from her mouth. In this cell she placed a pasty bit of nectar and pollen and laid one of her small eggs. She covered the cell tightly with one or more

From Department of Entomology

Leaf-cutter bee and a tube of its cells

smaller, rounder pieces of leaf. Then she built another and another cell above the first, perhaps as many as ten. When she had finished, she closed the burrow. One bee may make several such nests.

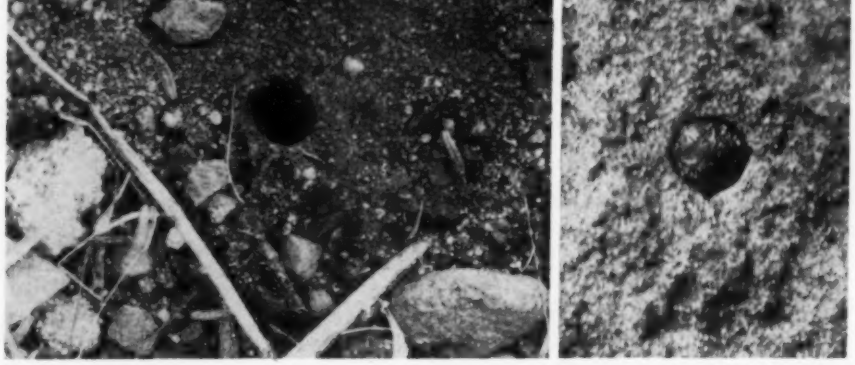
In the cells, the eggs hatch. Each larva feeds on its store of food, changes to a pupa, and then to an adult. The oldest bee at the bottom of the nest usually has to wait to get out into the world until its younger brothers and sisters have gone.

There are other kinds of leaf-cutter bees. Each makes its own kind of nest, usually choosing a special kind of leaf. Some use flower petals.

A tiger underground. Have you ever walked along a dusty road or a hard-packed path on a hot sunny day in summer, and noticed a large, metallic-green beetle about ½ inch long just ahead of you? Did it remain quiet as you approached, then, like a flash, fly up and alight some distance ahead, often turned so that it faced you? It probably was one kind of tiger-beetle—there are many kinds that differ in size and color.

These beetles hide at night and in cloudy or rainy weather in holes in the ground or under stones or rubbish. They are active hunters of other insects and similar small creatures, and usually live in open, sandy places. The adult beetles hibernate in winter, each in a separate burrow, usually about 5 inches deep, often extending under a stone.

Tiger-beetle larvae are perhaps even better burrowers than the adults. Dr. Frank E. Lutz, who



From Department of Entomology

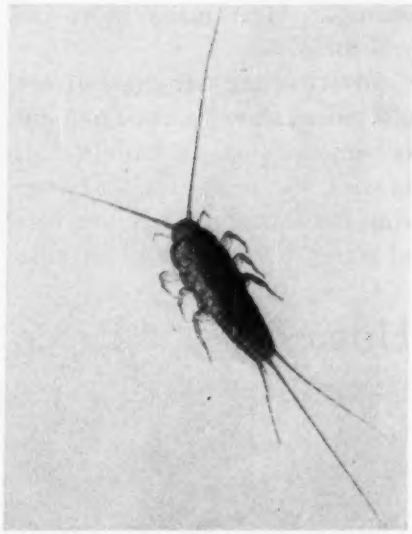
Tiger beetle burrows

Left, an open burrow; right, a larva at the mouth of its tunnel

wrote one of the books listed on page 32, once showed me their burrows in a sandy place on the Cornell campus—they burrow also in beaten paths or in dry, hard, plowed fields. Dr. Lutz showed me how to thrust a grass stem or a straw down into the burrow and jerk out the larva when it clutched the intruding stem.

The burrows of tiger-beetle larvae often extend straight down for 1 foot or more. The larva's usual place is near the mouth of its den. Its dirt-colored head plugs the hole, and its strong jaws extend upward ready to seize the first insect that comes within reach. A hump, furnished with two hooks, near the end of its abdomen, helps to keep the larva from being pulled out of its hole by some strong insect it has caught, and also helps it to drag its prey below ground, to be eaten at its leisure.

Other homes to look for. These are only two of many kinds of insect homes in cracks, crevices, burrows, and tunnels. Some insects, such as crickets and ground beetles, live beneath a stone, a board, or any other convenient shelter. Bumblebees often make their homes in deserted mouse nests. Some kinds of wasps dig burrows in which to place their eggs, and stock them with paralyzed insects for the young to eat. One kind, called the *great golden digger,* uses certain kinds of grasshoppers. Another is known as the *cicada-killer* because it preys on those large, noisy insects. Ants of many kinds are expert diggers and builders, and there are many others. Some are certainly well known to many of you, but whatever the kinds of insect houses you find in such places, you may be sure that each has its own special story.



From Department of Entomology

A silverfish, x about 2

Indoor Homes

Inside our homes and other buildings, insects that live in cracks, crevices, burrows, or tunnels usually are pests. The silverfish, illustrated on this page, is an

example. How many more can you think of?

Silverfish are wingless, silvery, glistening, scaly insects. Frequently they are pests in laundries, libraries, and museums, and sometimes in houses. They are fond of starched clothes and curtains, the bindings of books, wall paper, and other things on which paste or glue is used. They usually lurk in dark places, and scurry to shelter when they are disturbed. Unlike most kinds of insects, they just grow from young to adult without metamorphosis.

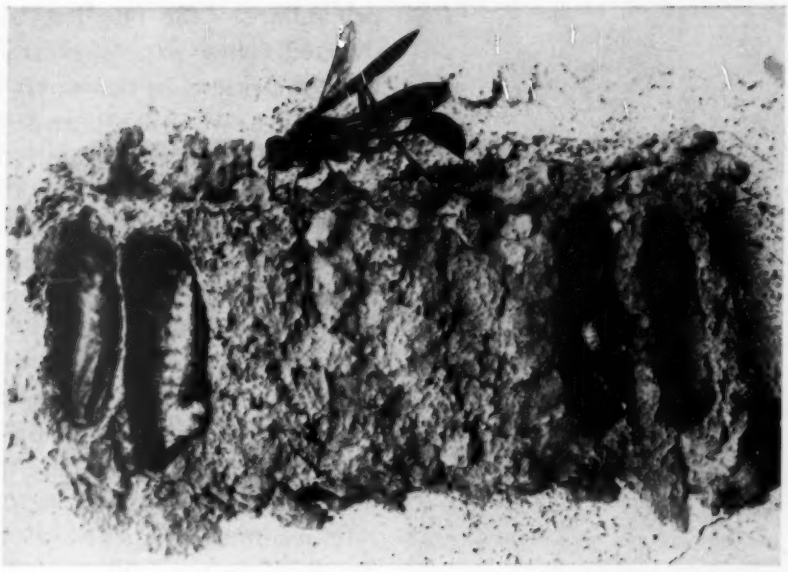
Homes of Mud, Paper, Silk, and Other Materials

Nest of jug-builder wasp

DAINTY little jugs like those pictured on this page are made by small, slender-waisted, dark brown wasps with yellow markings. Their "mortar" is sand or gravel, mixed with mud and saliva, and sometimes strengthened with hair. A female may make several jugs.

Inside each jug, the mother places caterpillars, still alive, but paralyzed by well-placed stings. She puts in enough to feed the grub that will hatch from the egg she fastens inside the top of the jug. She closes the jug with a cork of mortar. The grub hatches, feeds, changes to a pupa, and usually in late summer, breaks through the thin walls of its home, an adult wasp.

A black-and-yellow wasp makes mud nests like that shown on page 27. With her jaws she collects small balls of mud which she mixes with saliva. She attaches her building blocks to ceilings or walls of buildings, or in other dry places. A complete nest usually has several tubes, each about 1 inch long, placed side by side, and plastered over with "adobe." As each tube is finished, the wasp packs it with enough paralyzed spiders to feed one of her young, lays an egg inside, and closes the tube with more mud. The plump, whitish grubs hatch, feed, pupate, and finally bite and scratch their way through the mud walls. Young females spend the winter in protected places, often inside houses.



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Mud dauber wasp and nest, slightly enlarged

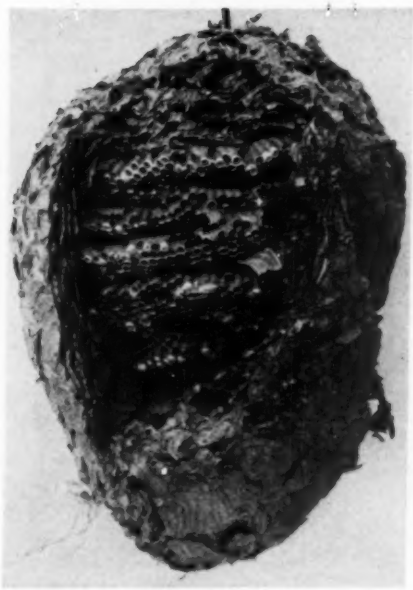
This nest was removed from a wall, exposing the cells. These contained (from left) a full-grown larva; a pupa; and a young larva feeding on spiders. The fourth cell was empty.

Other workers in mud make houses of different shapes and sizes, located in various kinds of places. They provision their nests with different kinds of food.

Insect homes of paper are well known to most of you—and carefully avoided while they are occupied. Our familiar paper-makers are the yellow-jackets, the white-faced hornets, and the Polistes wasps that often hang their single-layered nests around buildings. Our common yellow-jackets make underground paper nests in cavities they find.

Wasp paper is made of wood pulp (as is much of the paper we use every day). The wasp's paper-making "machines" are her mandibles (jaws) and her tongue. The material she uses is weatherworn wood, bits of which she shaves off with her jaws. Chewed to a pulp and mixed with a gummy secretion from her mouth, it becomes paper that is built into the nest wherever it is needed.

Wasp "combs" are all single (not made of cells placed back to back as are those of honey bees), and the paper cells open down-

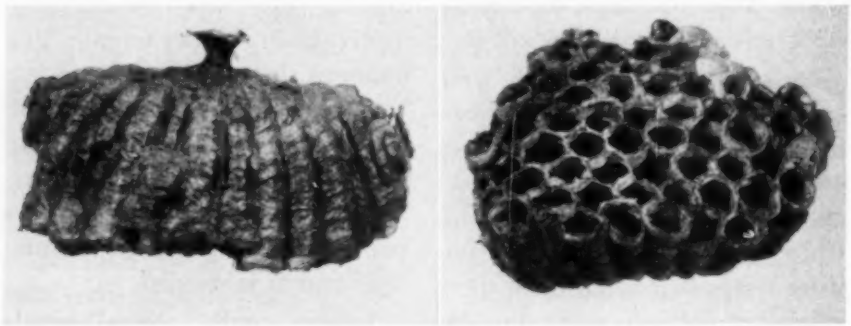


From Department of Entomology

Nest of white-faced hornet with wall removed

ward. Wasps that make more than one comb—Polistes does not—begin building at the top of their nests and work downward, attaching each new comb by a paper pillar to the one last constructed. These paper-makers enlarge their nests in two ways: by adding new combs, and by "building on" cells around the edges of old ones. Those that cover the combs with paper rebuild and add to the wrappings of their nests to keep pace with the inside enlargements.

How the wasps live and what goes on inside the paper houses, I shall leave you to find out for yourselves. Sometime in late fall, after hard frosts have made it safe, examine a paper-wasp nest. Small white eggs, plump, white grubs, and pupae in capped-over cells, (these sometimes contain adults just ready to emerge) all may be found. You can see, too, the layers of paper cells, held together by the central paper pillar. Is the paper fairly tough? Does it shed water easily?



Single-combed nest of Polistes wasp *Photos by R. B. Fischer*

Left, from side, showing stalk by which the nest was hung under eaves of a shed; right, underside showing downward opening cells. An adult ready to emerge is at upper center.

In much of New York State the silken houses of apple-tree tent caterpillars are all too common. Here a whole group of insects work together to build a silk tent in a crotch of a tree. As they grow, they make their nest larger. They "stay at home" at night and in stormy weather, but on good days go out on the branches to eat. The caterpillars leave the tent, when they are full-grown, and each makes its own silken cocoon. A mimeographed bulletin, obtainable from the Cornell Rural School Leaflet Office, Ithaca, New York, tells more about them.

From Department of Entomology

Apple-tree tent caterpillar nest
Nests should be destroyed when they first appear.

By early May and through the summer months insect homes of sticky white froth are common on many kinds of shrubs, grasses, and other plants. Inside the bubbly mass you probably will find a small, squat insect, or perhaps two or more. They are young spittle insects, often called *spittle-bugs* or *frog-hoppers.* They make their homes of many small air bubbles held by sticky material made of plant sap and other substances. Protected by their frothy covering, they pass through a gradual metamorphosis. Adult spittle-bugs look somewhat like tiny frogs, and can leap nimbly among the plants on which they live—without a covering of froth.

From Department of Entomology

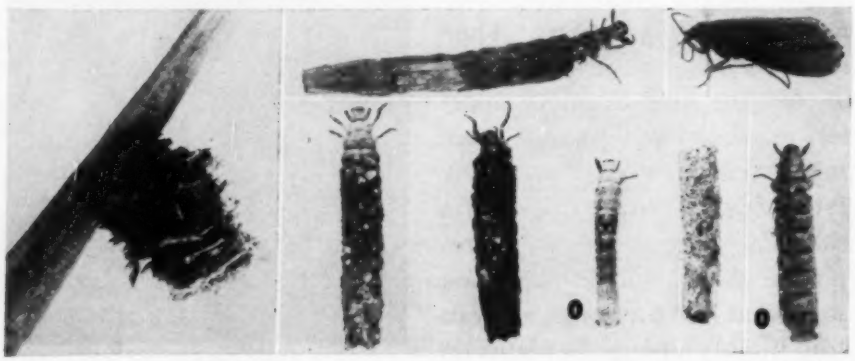
Spittle insects on grasses
The frothy masses give protection to their makers.

Underwater Homes

You might call the underwater homes of many kinds of caddis-worms submarines or, perhaps, underwater trailers. They are made by their owners, and most kinds are dragged around wherever their makers go. As you can see in the illustration, caddis-worm cases differ. Each insect, when it can, chooses the kinds of materials and the style of architecture adopted by its close relatives. Only a few kinds are not case-builders.

You will find caddis-worm cases in quiet ponds, and also in flowing water such as creeks or brooks. If you discover some, put a few in jelly-glasses or similar small 'aquariums," in water an inch or so deep. Notice that most cases have a front and a back "door." Sometimes if you poke gently through the back door with a stem or something, you can make the larva crawl out of its case. Take the case away, and give the caddis-worm bits of material as nearly as possible like those it chose for its case. In our laboratory, "log-cabin" caddis-worms like the one below (left) often have made new cases of small cellophane strips. You will find case-making interesting to watch.

Caddis-worms hatch from eggs, and spend their larval and pupal stages in the cases. The adults are dull-colored moth-like insects with long slender antennae, and four more or less hairy wings. They are common near waterways, and often gather around lights at night.



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An adult caddis-fly (upper right); some types of caddis cases and two caddis-worms (marked 0), removed from their cases

A Final Word

THIS Leaflet, *Insect Homes,* comes to you as a winter number, but insect homes belong to no one season. You can find them at any time of year. They are worth becoming acquainted with, whether they are occupied or deserted. You may not discover all those mentioned in this Leaflet, but you will find some of them, and perhaps many others. The references listed on pages 31 and 32, and others you will find in libraries will help you learn about those you discover. Perhaps they will suggest others to look for.

You will learn much about insects and their ways, as you examine the insect houses you find, and as you discuss them at home and at school. It is fun just to know such things, but your knowledge may also be valuable to you. Many insect makers of houses are serious pests about which you need to know. Others are beneficial in one way or another—and you need to know about them, too.

You may decide to try to rear some of the insect larvae or pupae you discover. A good rule to follow is to give them as nearly as possible the conditions (temperature, moisture, light, and the like) that they would have naturally in the place where you found them. Put them where you can keep an eye on them. Protect them from enemies, and prevent their escape so you can be sure to see what happens. Then, have patience—you may have to wait a long time.

You can start your studies as soon as you finish reading this page. Some of you will find insect homes a good summer hobby, and the source of many interesting studies when you return to school next fall. Good luck, and good hunting.

Some Helpful Books and Phamphlets

Cornell Rural School Leaflets, especially: *Land Insects,* November, 1922; *Pests of Plants, Pets and People,* January, 1925; *Fall Insects,* November 1931; *Homes,* January, 1938; *Waterways in Fall,* November, 1938; *Apple Tree Animals,* March, 1948.

4-H Club Insect Manual. By M. P. Jones. United States Department of Agriculture, Miscellaneous Publication 318. Superintendent of Documents, Washington, D.C. 1940. 63 pages. Inexpensive and helpful. For grade 6 and up.

Sphinx, The Story of a Caterpillar. By Robert McClung. William Morrow and Company, New York City, 1949. 48 pages. True story of a tomato worm. For children 6 to 10.

Insects and Their Ways. By Bertha M. Parker. Row, Peterson and Company, Evanston, Illinois. 1941. 36 pages. Easy to read. Well-illustrated. For grades 4 to 6.

The Tale of the White-faced Hornet. By Henry B. Kane, Alfred A. Knopf, Inc., New York City. 1943. 48 pages. Well written, beautifully illustrated. For grade 4 and above.

Insects: A Guide to Familiar American Insects. By Herbert S. Zim and Clarence Cottam. Simon and Schuster, New York City. 1951. 157 pages. Small, helpful book, illustrated in color. Grade 4 and above.

The Junior Book of Insects. By Edwin Way Teale. E. P. Dutton and Company, New York City. 1953. 249 pages. General information and suggestions for studies. Grade 6 and up.

The Insect World. By Hilda T. Harpster. Viking Press, New York City. 1947. 211 pages. Interesting, readable. For upper-grade children and teachers of elementary grades.

Handbook of Nature Study. By Anna Botsford Comstock. Comstock Publishing Company, Ithaca, New York. 1939. 937 pages. More than 100 pages about insects. For teachers and older students.

Entomology for Introductory Courses. By Robert Matheson. Comstock Publishing Co., Ithaca, New York. 1951. 629 pages. Useful reference for teachers and older students.

Fieldbook of Insects. By Frank E. Lutz. G. P. Putnam's Sons, New York. 1935. 510 pages. Many illustrations and brief information. For teachers and older students.

An Introduction to Entomology. By John Henry Comstock. Comstock Publishing Company, Ithaca, New York. 1940. 1064 pages. For teachers and older students.

Leaf-mining Insects. By James G. Needham, Stuart W. Frost, and Beatrice H. Tothill. Williams and Wilkins Company, Baltimore. 1928. 351 pages. For older readers.

Plant Galls and Gall Makers. By Ephraim P. Felt. Comstock Publishing Company, Ithaca, New York. 1940. 364 pages. Standard reference. For teachers and older students.

Insects. United States Department of Agriculture Yearbook 1952. Superintendent of Documents, Washington 25, D. C. 780 pages plus 72 colored plates. For teachers and older students.

The New York State College of Agriculture, and the New York State Agricultural Experiment Station at Geneva, publish bulletins useful in this field. A *List of Publications* may be had from the New York State College of Agriculture, Ithaca, New York.

The New York State College of Forestry, distributes valuable free leaflets on insect pests. Write to *Tree Pest Information Service,* State University College of Forestry, Syracuse 10, New York.

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